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AFIT/GIR/LSY/90D-4

A TELECOMMUNICATIONS APPROACH TO UPDATING TECHNICAL ORDERS

THESIS

Charles W. Fox, Captain, USAF

AFIT/GIR/LSY/90D-4

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A TELECOMMUNICATIONS APPROACH TO UPDATING TECHNICAL ORDERS

THESIS

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of the Air Force Institute of Technology

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In Partial Fulfillment of the

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Masters of Science in Information Resource Management

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Captain, USAF

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Abstract

The Joint Uniform Service Technical Information System (JUSTIS—formerly the Air Force Technical Order Management System) was chartered to improve the way in which the Air Force and other services manage technical orders (TOs). Because of the involvement that TOs have in the way the Air Force does business and over 20 million TOs that must be managed (with 2.3 million page changes annually), the effectiveness of the technical order system significantly impacts military readiness and the Air Force budget.

Much of the current system does not meet today's complex Air Force needs. This report investigates the ramifications of transmitting TO changes over the Digital Defense Network (DDN)—specifically MILNET, taking into consideration cost, security, data integrity and configuration control. From an investigation of the technical order system, DDN, and digital computer storage media, a model was developed to determine the viability of the author's hypothesis. The model is a simple, straightforward description of a solution to updating TO changes. In order to determine benefits and shortcomings in the model, a variety of experts reviewed the model and answered specific questions.

A TELECOMMUNICATIONS APPROACH TO UPDATING TECHNICAL ORDERS

I. Introduction

Objective

The Joint Uniform Service Technical Information System (JUSTIS) [formerly the Air Force Technical Orders Management System (AFTOMS)] was chartered (and later endorsed by the Secretary of the Air Force) to improve the way in which the Air Force manages its technical orders (TOs). The life cycle of the TO includes specification, acquisition, delivery to and use by Air Force and other Department of Defense agencies, maintenance by various government contractor agencies, storage, and recision. Because of the involvement that TOs have in the way the Air Force does business and over 20 million TOs that must be managed (3:2), the effectiveness and efficiency of the technical order system significantly impacts military readiness and the Air Force budget.

The Department of Defense Computer-aided Acquisition and Logistics Support (CALS) initiative was implemented to standardize and specify delivery and use of digital technical data by government agencies. CALS mandates that the delivery of digital technical data will be in standard format in order to enable easy integration into the TO system (4:2-1). However, the Air Force lacks the means to manage and distribute digital TO data. This deficiency has been noted by the Secretary of the Air Force and was later commented upon by the Chief of Staff, USAF: "I believe the AF should make a commitment to transition from our current paper intensive TO processes to a highly automated and integrated mode of operations by the mid-1990s" (4:2-1). One aspect of the JUSTIS project is to review, recommend improvements, and implement a distribution process for digital TOs. Developments in computer storage technology may offer opportunities in the way Air Force

TOs are stored and distributed. Recent laser disk technological developments, such Compact-Disk Read-Only-Memory (CD-ROM), Write-Once Read-Many (WORM) disks, and erasable disks, offer a means of storing large quantities of data in a compact space. Any of the above-mentioned disks can hold at least 270,000 pages of text or 10,000 pages of text and graphics (30:24).

Specific Problem

JUSTIS will soon release the information necessary for contractors to develop a system to support the distribution of TOs which are now being distributed in paper form. The objective of this paper is to investigate and propose a TO change distribution plan in coordination with JUSTIS that would enable TO updates to be distributed via a telecommunications network. This paper will investigate the ramifications of transmitting the data via telecommunications, taking into consideration cost, security, data integrity and configuration control. Further, it will investigate similar concerns regarding the digital storage of TOs at base level and subsequently recommend a model by which TOs would be transmitted to, and accessed for further distribution at, base level. Finally, in order to give validity and credibility, the model will be presented for critique by experts in the fields of data storage, data communications, and TO management. Research would result in offering directions which JUSTIS could take in its current development, considerations it may wish to implement in the future, or alternatives which it should avoid.

Investigative Questions

The research questions are divided into three categories, covering the entire process of distributing TO changes. The first set addresses background issues regarding TOs and JUSTIS. Next, transmission of technical orders from the source to base level is studied. These questions are to verify the feasibility of transmitting the kinds and quantity of data

inherent in the TO change process. Finally, the third category provides direction to help develop a method by which the TOs can be stored and accessed at base level.

Background.

1. How are TOs currently created and subsequently updated (in ways pertinent to this study)?

2. How will TO configuration control, and the specific nature of TO changes, impact a telecommunications solution?

3. How will JUSTIS affect any update procedure?

Data Transmission.

4. What requirements must be met to transmit TOs electronically over available resources?

5. Can the Defense Data Network meet expected transmission needs?

Storage and Distribution.

6. How should the transmitted data be stored at base and ?

7. What will be the cost?

Scope of the Research and Assumptions

This investigation will consider the transmission of data from the origin. It will not study how the data were prepared for transmission. The types of information to be considered include textual, graphical, and classified. The information to be transmitted is assumed accurate and complete. Further, only updates to technical orders will be considered; the hypothesis on which this paper is based is that only the actually modified portion of a TO needs to be transmitted to the user. Transmitting an entire set of TOs with each TO modification would make this telecommunications method impractical. Consider that the B-1B set of TOs alone consumes one million pages (2:14).

The other part of the telecommunications model is data storage and distribution at base level. Transmission beyond the central repository level, which includes distributing data to the flightline and access there, will not be investigated. The responsibility of of

local distribution lies with the Major Commands (and will probably be implemented with Local Area Networks). The Aerospace Systems Division (ASD), Human Relations Laboratory is developing a means to access digital information at flightline level (13:1).

To consider all parameters of the complete JUSTIS distribution system is beyond the scope of this paper. Time would not permit such an investigation. Moreover, it may not be cost effective to develop a TO telecommunications system to encompass all TOs. Because of the number of updates that are made to weapon system TOs and the cost involved, a sufficient monetary savings must be realized here to justify digitizing a TO (13:1). Therefore, this paper will consider only those TOs concerned with weapon systems at base and depot level.

Problem Background

"The availability and ease of access to current and correct technical data is an absolute necessity to assure high quality maintenance and operation of Air Force systems" (3:1). If size is any indication of the involvement which TOs play in our ever-changing Air Force, consider that the total TO database is approximately 20 million pages with about 2.3 million pages changed each year (3:2). However, the current TO distribution system, designed in the 1940s (2:1), has not remained in step with the growth in size and complexity of the Air Force. It suffers from a variety of deficiencies. Consider the following examples:

1. The average-sized TO is 100-150 pages. The extant system requires the user to order an entire TO to replace just a single page that has been destroyed or soiled (3:2).

2. The Air Force Logistics Command alone has 340,000 square feet of floor space dedicated to TO storage (3:3). The B-1B will require an additional 17,000 square feet requiring $2.7 million per year (2:14).

3. A new weapon system can easily add five percent to the current inventory of 20 million pages, as with the B-1B, B-2, B-17, and Advanced Tactical Fighter. Thus each new weapon system significantly compounds problems (2:14).

4. Requisition of TOs requires 45 days and, at extremes, 120 (3:4).

5. The TO change process averages 270 days for routine changes (2:7).

6. From 1977 to 1986, incomplete, difficult to read, inaccurate, etc. technical data was a contributing factor in 47 percent of Cause Code I mishaps. These mishaps cause in excess of $95 million in equipment loss or damage (2:14).

These are just a few of the inadequacies with the status quo. A variety of changes in current procedures and automated support are being designed by JUSTIS to improve this antiquated system. One deficiency of the current system, as mentioned above, is the change distribution method. This process requires considerable warehouse space and has been a contributing factor in equipment loss and damage. JUSTIS is seeking a system to distribute TOs which will likely employ optical disks in the form of either CD-ROMs or WORMs as the medium.

JUSTIS is an enormous operation, with a budget of $1.1 billion approved to revamp the system (37). JUSTIS will contract out to private organizations who will in turn suggest a method of TO distribution. A solution could be, for example, to periodically distribute a "suite" of TOs on optical disk. A suite includes all the TOs pertinent to one weapon system such as all TOs which describe F-15E maintenance. While an optical disk as a storage medium may be the only option because of the amount of data pertaining to any particular weapon system, forwarding a disk may not be the optimal method. Consider this likely scenario. The B-1B TO database (totalling 1 million pages) will require many 5-1/4 inch optical disks based on the knowledge that up to 270,000 pages solely of text can fit on one disk; only 10,000 pages fit when the data is comprised of half text and half graphics (30:24). TOs in general are comprised of 60 to 70 percent text and 30 to 40 percent graphics (3:2; 8; 28). Any small change to a TO, say that occurs monthly, requires the distribution of at least one new disk. To distribute the disk, an optical disk must be mastered at a cost of $10,000 to $60,000 (29:71). Of course, there is also the cost of "pressing" the disks. Copies cost $3 each if more than 50 and fewer than 5000 are purchased (42:226). Then the cost must be paid to mail each disk, or set of disks, to units.

Certainly this method might well solve change distribution inadequacies and cut costs. Yet this may not be the least expensive most expedient method. As budget cuts loom on the near horizon, a cheaper, faster, and potentially more progressive method would be welcome. Instead, it may prove to be more cost effective and expeditious to distribute the information electronically.

Previous Research

A considerable amount has been written on the storage of large quantities of information using optical disk. The Army and Air Force have combined a system to replace their respective repository of technical drawings of weaponry and place the information on WORM disks. In 1984, the IRS awarded a $3.7 million contract to Integrated Automation of Almeda, California "to develop a digital imaging system" that will eventually place approximately 50 million documents on optical disk (22:7). Lind used CD-ROM to store over 2 million data base records at the Naval Supply Center in Oakland and pressed them to a single CD-ROM (30).

No research has been done regarding the transmission of data to directly update data bases (8).

II. Methodology

Introduction

This chapter discusses the approach used to investigate the transmission of information and storage of data. The approach is a survey of current literature, regulations, technical orders and interviews with experts. The chapter also includes discussion of the method to test the author's telecommunications model.

Justification and Instrument

The best approach of investigating and evaluating technical orders, data transmission, data storage, and testing the proposed model are different. Therefore, each discussion has been divided into its own respective section. Because the purpose of this study is similar to a literature survey, and not to perform analysis on information collected through questionnaire, the justification and instrument sections (which are often divided when employed in the latter type of study) are united.

Technical Order Background. The perusal of technical orders giving policy on TOs and discussion with individuals at JUSTIS will provide background information. This information will provide the reader with a general "feel" for the subject, thus providing him or her with sufficient information to observe any potential problems in the author's recommended solution. Interviews with individuals who work with JUSTIS and information from TOs and related JUSTIS documents (e.g. JUSTIS Statement of Need) will balance out the information quest.

Data Transmission. Data transmission in the Department of Defense has shown reliable over many years of use. Consequently, much of the information needed in this paper can be found in literature, telecommunications system documentation, and interviews with experts. While the intent of the investigation of data transmission is not to make any

discoveries, it is essential to establish that this aspect of the proposal is feasible, and to reveal obstacles or limitations that must be overcome. Further, this is the foundation upon which the proposed data storage model rests. Such factors as cost will be sought through personal interviews. A literature review of this topic includes current periodicals, books, documents regarding Air Force transmission resources, and availability of other network telecommunications sources. Non-formal interviews with individuals belonging to the Defense Communications Agency and Air Force Communications Command will certainly offer valuable information.

Data Storage. This portion of research deals with the investigation of literature for the development of a model for the storage of technical orders at base level. The plan deals with information systems on the leading edge of technology (e.g. optical disks) and must incorporate the transmission aspect of the preceding section. No such plan exists. Journals will be the primary resource of information here; because of the nascence of, and rapid advances in, optical storage, few books are sufficiently current. A literature review here will elicit information about the potential of the hardware necessary for this plan. Reasonably stable, well-established storage media will be researched with one suggested as a storage alternative for the model.

Hypothesis Testing. To give merit to the author's model, it needs to be evaluated. Since actually implementing the model is impractical, the testing will be performed by experts in the fields of telecommunications, computer storage, and technical order management. Each part of the model must undergo a "reality check." The experts will determine whether the author's proposed model is a viable option. In order to test the proposed model, a questionnaire will be formulated and sent with an outline of the model to approximately 10 individuals. The following list describes the evaluation process:

1. The recipients will be asked to respond to questions after being provided with a brief synopsis of the model.

2. The model will largely describe procedures to execute one TO update cycle, that is sending one TO change from origin to base.

3. The questions will answer whether a weakness exists in the model which will result in a failure to produce the desired output.

4. Once the information is collected and processed, weaknesses in the model would be addressed.

Expert Selection and Questions. The topics of expert selection and the specific question posed to the experts is addressed in Chapter VI.

III. JUSTIS Area of Focus

Introduction

This chapter is divided into three sections which form the bulk of background investigation in this thesis. The first section investigates the pertinent areas of the current technical order creation and subsequent updated processes, and on JUSTIS. This information will provide the reader with a general understanding of the technical order life cycle and provide him a basis on which to determine what factors need consideration in the TO update and distribution process.

The second section takes a look at data transmission as it relates to the author's hypothesis. Areas considered include TO transmission requirements which must be met to transmit TOs electronically. Also, available transmission resources are examined to ascertain whether they will meet expected needs. The third section address the following topics:

1. Security,
2. available storage media and devices, and
3. a portion of the JUSTIS distribution plan.

Examining the aforementioned areas provides the basis for developing a model. The model is used as a means to test whether such a system can be implemented and whether any aspects have been omitted. The subject of testing the model is addressed in Chapter VI.

Background

General. Technical orders are published by AFLC and AFSC, with AFLC assuming the responsibility of distribution. As such, AFLC is the focal point for determining requirements for technical orders (TOs). Major Commands (MAJCOMs) and Separate

Operating Agencies (SOAs) assist AFLC in determining Air Force-wide requirements for TOs (12:1-7). They are issued in a variety of different formats, including hard copy, microfilm, and TO indices issued as microfiche; they are also transmitted both electronically and through the US Post Office (12:2-3). Because of the critical nature of TOs, pen and ink changes (that would be less expensive and more expeditious) are unauthorized (12:4-1). Consequently, this prohibits the user from modifying TOs at unit level as Air Force regulations are.

For the TO to be useful in a military maintenance environment, it must be accurate, precise, adequate in depth and coverage, and provided to the user in a timely manner to reflect the current configuration of the equipment being covered (2:1). The need for timeliness necessitates that TOs to support a new system be acquired on a time-phased schedule. This schedule is formally imposed on contractors to meet the requirements for acquisition, review, validation, verification, correction, and delivery of TOs to the operating unit, concurrent with the delivery of the hardware (11:7). The acquiring activity with program responsibility budgets for and funds all TO requirements, changes, and MAJCOM support required during TO development as long as it is responsible for it (i.e. until Project Management Responsibility Transfer) or termination of the acquisition contract. The cost of acquiring TOs includes writing, editing, preparing reproducible copy, and printing (11:10). The following discussion details these topics more closely.

Technical Order Definition. There are several different types of technical orders and even different ways to describe the same type of document. In this context, technical order (TO) and technical manual (TM), used in the generic sense, constitute the same meaning. A TO is a military order and is issued in the name of the Chief of Staff, US Air Force, and by the order of the Secretary of the Air Force (11:2). TOs serve as the primary educational and operational tools supporting the Air Force-wide maintenance program (2:1). Air Force systems and equipment, with some exceptions discussed below, are operated and maintained according to procedures described in the TOs. The Air Force does not field systems

to be operated and maintained without verified TOs (11:2). The types are categorized by: 1) form of delivery; and 2) content. A more complete understanding of TOs is gained from reviewing the content category:

1. Technical Order (TO): Contains instructions designed to meet the needs of personnel engaged or being trained in the operation, maintenance, service, overhaul, installation, and inspection or equipment and material. The TO may deal with specific aircraft, missile, and communications-electronics (C-E) systems and items of equipment, or may deal with a subject area such as welding or painting.

2. Methods and Procedures Technical Order (MPTO): An MPTO establishes policies and provides information and instructions on maintenance management or administration, configuration management, and so forth.

3. Time Compliance Technical Order (TCTO): A TCTO includes instructions for modifying equipment, performing or initiating special "one time" inspections, and imposing temporary restrictions on aircraft flight, missile launch, or usage of airborne and ground C-E equipment, and support equipment

4. Index TO: An Index TO shows the status of all TOs and provides personnel with a means of selecting needed publications.

5. Abbreviated TO: This is primarily a work-simplification device, such as a checklist, inspection workload, or lubrication chart.

There are subjects excluded from the TO system that are not required to adhere to the same criteria. They include, for example, contractor-operator experimental equipment and computer programs and computer program documents managed according to AFR 800-14.

Technical Order Creation.and Changes

The technical order development cycle is closely tied to the weapon system life cycle. The weapons system starts with a Statement of Need (SON) (33). A SON states that to satisfy Air Force mission needs, perform them more efficiency, or both, a new weapon system is needed. This development cycle is long and detailed, and for the most part outside the scope of this paper. However, a graphical depiction of the process can be found in Figure 1. There are two aspects of the cycle which need consideration. First, the

Production and Deployment Phase deals with the method of storing TOs at unit level. This largely impacts the initial distribution and storage medium. Second, the security classification of TOs needs to be considered. This too will impact distribution and storage requirements.

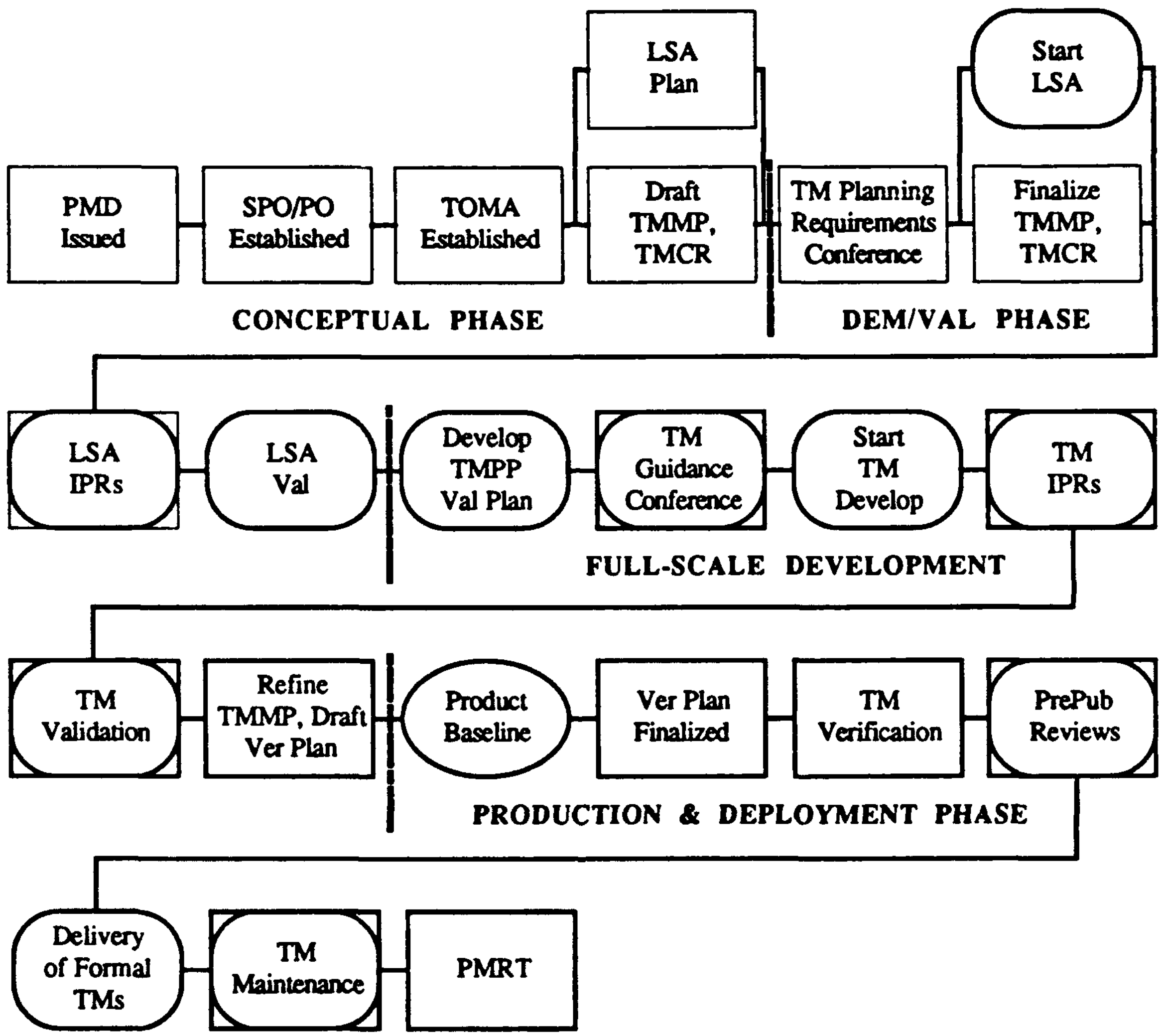

Figure 1. Technical Order Sequence Flow Chart (10:1-4)

Table 1. Glossary of TO Life Cycle Terms

Formal TMs	Technical information packaged and produced to military specifications and format requirements, verified to the maximum extent possible and released for printing and distribution through the government contract printing office.
IPR	In-Process Review
LSA	Logistics Support Analysis:
PMD	Program Management Document
PMRT	Project Management Responsibility Transfer
Product Baseline	Point at which weapon system is approved by the USAF
RFP	Request for Proposal
SPO/PO	System Project Office/Project Office
TM Maintenance	Technical manual maintenance includes periodic update and review.
TMCR	Technical Manual Contracts Requirements
TMMP	Technical Manual Management Plan
TMPP	Technical Manual Publications Review
TOMA	Technical Order Management Agency

Production and Deployment Phase. The product base line is the configuration of the weapon system upon approval. Although it may undergo subsequent changes in design, the original approval demarcates the beginning of this phase. The TOs will reflect this model. The verification plan initiated in the previous stage is finalized and actual verification begins. Following that is the pre-publication review (PPR). The PPR, which is optional, is designed to examine TOs upon completion of the reproduction copy but prior to preparation of reproduction media (10:7-4). Government inspection, in-process and pre-

publication review are required to ensure that they conform with format, style, technical content, changes resulting from verification, and other specifications or contract requirements and must be completed before the TOs are prepared and delivered (11:7). Using a digital medium will impact this process; it will mandate the inspection of the medium itself, production, etc. Consequently, this portion of the inspection process may change significantly. And each type of the medium will fashion the nature of the inspection process differently. With the deployment of the weapon system, TOs are also distributed to the system project office. Original printing and distribution to the field is the responsibility of the system project office, which also pays for the printing.

At some point in the last part of the system cycle, responsibility for the system is transferred to the Air Force Logistics Command. This process is entitled Project Management Responsibility Transfer (PMRT). No specific formula exists for when the transfer occurs. It is simply worked out between the two commands. With the transfer of the system goes the responsibility of maintaining and updating TOs.

Technical Order Security. Though not a phase of TO acquisition, the discussion would be incomplete without considering security.

> TOs may contain information up to and including Top Secret-Restricted Data. The classification of each paragraph and page containing classified information must be based on its contents and indicated in the prescribed manner. Title pages are marked to show the highest security classification of material contained in the TO. Classified TOs are reviewed by the management agency every 12 months, and each time they are changed, revised, or supplemented (11:10).

JUSTIS, however, manages TOs up to and including the classification of Secret (1:6-1).

The following excerpt pertains to the requirement of maintaining an audit trail.

> "The JUSTIS ADS must contain mechanisms that can be independently evaluated to assure user access is strictly controlled. . . . Audit information must be internally and selectively recorded so actions affecting security can be traced to the responsible party" (1:6-4).

Technical Order Updates and Distribution

Reason for Change. Recommendations to modify TOs are for the sake of "improvement, correction of errors, or omission of a technical nature which prevents the adequate performance of functions required for mission accomplishment" (11:5). In other words, corrections are made when they affect the meaning of instructive information or procedures. (This means that word omission and typographical errors in and of themselves are not sufficient reason to change a TO.) These are the types of changes that are propagated from the ground up: usually, individuals at base level identify a potential error (34). It also occurs that when a significant change in configuration occurs, such as a new series designator for a model or a system or equipment, a separate set of basic or supplemental manuals must be acquired (11:6).

Change Process. The update process occurs in one of two ways. This depends upon which part of the life cycle the weapon system is in when a change to the TO is needed—either before or after Project Management Responsibility Transfer (PMRT). The scenario is similar in each situation. Prior to PMRT, the AFSC systems project office is charged with the responsibility of reviewing and approving changes. After PMRT, the request is approved by the Equipment Specialist at a Air Logistics Center (ALC) responsible for that item rather than the AFSC SPO/PO. The TOMA provides the appropriate routing instructions for the change request (10:12-1).

Aside from the approval authority, the flow of a request is similar. A closer look at the post-PMRT change process will give the reader a more thorough understanding of the current system and its limitations.

TO Change Request. TO procedural changes are most often initiated by the user because there is a perceived discrepancy (34); in fact, it is a requirement to submit a report under such circumstances (12:6-2). The request may correct or clarify data, and include handwritten narratives, drawings, copies, or photographs as attachments (1:2-31). The

user completes a TO Change Request Form, AFTO Form 22. The individuals supervisor ensures the validity of the report and forwards it to the quality assurance office, probably located within the deputate. Depending on the impact of the discrepancy, the report may be treated more expeditiously. There are three categories:

1. Routine reports, the lowest, are replied to within 45 calendar days after receipt at the ALC and published within 210 calendar days.

2. Urgent is the next most important category. "The activity responsible for correcting a deficiency will take corrective action in the form of a TO change, revision, or supplement which will be published and distributed within 40 calendar days" (12:6-5).

3. The Emergency category includes the most serious discrepancies. They are acted upon within 48 hours with a Time-Compliance Technical Order (TCTO), interim Safety or Operational Supplement, or by downgrading or disapproving the report. A graphical example is given at Figure 2.

The downgrading or disapproving occurs at command level.

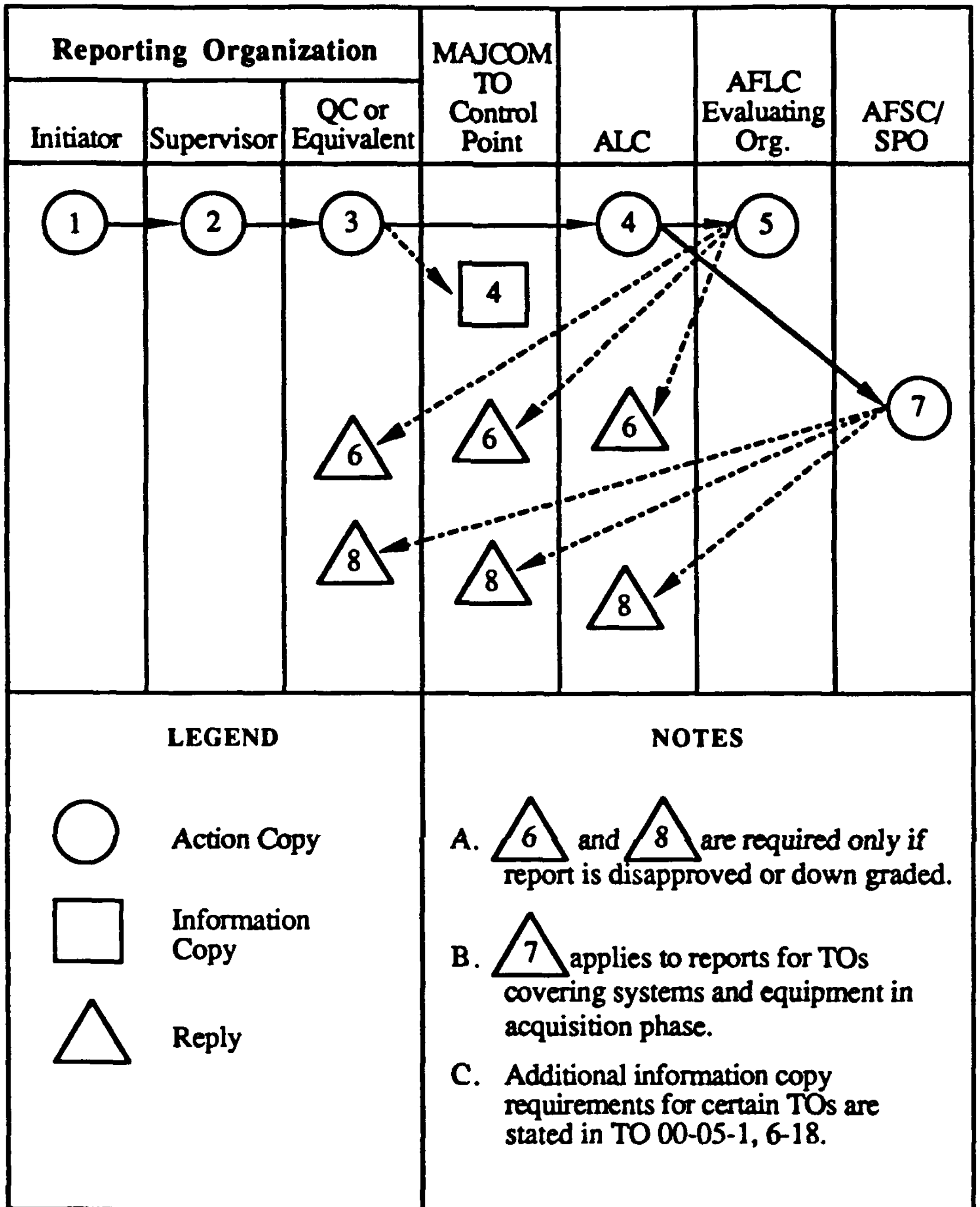

Figure 2. Emergency Flow of Emergency AFTO Forms 22 (12:6-15)

Usually the TO leaves the base-level organization 30 days after it is initiated provided it is neither an Urgent or Emergency report. The report is next routed to the command control point for review and to eliminate duplicate reports. Disapproved reports are returned to sender (12:6-4). Requests for change remain at an ALC on average 180 days.

The ALC backlog is the result of insufficient resources, too few people, and a lack of experience to keep up with the number of requested changes (34). Upon approval, the change is reproduced by the government or, more likely, forwarded to a government printing office. The change is accompanied by the List of Applicable Technical Orders (LATO). The LATO consists of an Initial Distribution Requirement for technical data that is applicable to a specific aerospace system and to one or more organizations (12:10-1). The LATO is maintained by the G022 computer system.

The G022 is a 1960s batch-processing computer system employed for management of the TO inventory (1:2.3) The products produced by the G022, including management reports, "are predominantly paper copy, are not real time, and do not depict the required information to make management decisions" (1:2-4). The G022 also maintains requirements made by Technical Order Distribution Offices (TODO) at base level (25). These TO requirements are necessary for a particular activity to perform its mission. When a TO is updated under routine circumstances, it is sent to a Government Printing Office with address labels. Printing and forwarding the changes from the government printing office consumes 20 to 30 days. The printed TOs are shipped to the responsible government agency who performs distribution to the TODO; excess TOs are stocked in the prime ALC's warehouse (1:2-39,40).

TO Change Approval. If the change request is approved, the ALC may reply to the originating organization. The proper procedure for changing the TO is to replace the corresponding numbered pages with all replaced pages being removed from the TO and discarded. When a change contains additional material that is too long to be fully included on a single replacement page, additional pages are issued and inserted between or after the affected pages. Additional pages are assigned the preceding page number plus a decimal point in consecutive order (e.g. 2-4.1). Pages added after affected pages continue in numerical sequence (12:4-2). To process a routine TO change requires eight to nine months, not including delays caused by a user not specifically stating the problem.

TO Revisions. It may occur that a TO needs revision. Revisions are second or subsequent editions of a manual that supersede the preceding edition. There are two types of revision: 1) update and 2) complete. An update revision incorporates all previous changes, supplements, and new data into the basic TO that would have required a separate change. This type of revision requires only minor reorganization or rewrite of the manual content. A complete revision requires reorganization *and* rewrite of the manual content. The determination of the need for a revision will be based on factors such as "the impact of change and supplements on the usability of the TO, urgency of need for change, cost, quality of stock on hand, and the existence of a reprint incorporating existing changes" (12:4-4). When possible, a black vertical borderline indicates changes in the text of a revision which were not previously published as TO changes or supplements.

Supplements are issued to augment or modify data in the basic TO. Supplementing supplements is typically not authorized, as for example with TOs, TCTOs, and checklists (12:4-4)

TOs are rescinded for Air Force use when the information is no longer required, is incorporated in other publications, or the rescission date of a TCTO has expired (12:4-6).

Specific TO Change Concerns

Configuration Control of TO Data. Configuration control is a widely used term pertaining to TOs and many aspects of JUSTIS. Here, configuration control is the management of TO data necessary to ensure that the appropriate information is applied to a resource. Inadequate configuration control may manifest several problems potentially resulting in the degradation of weapon system mission capability. For example, TOs dictate (or control) the way an aircraft is configured (provided the TOs are adhered to). Consider several aircraft of the same model in different phases of a modification process; each aircraft requires TOs applicable to its particular status. Consequently, several sets of TOs with different degrees of currentness must be maintained.

Further, there may be a concern when activities receiving TOs at different times have differently configured weapon systems because each system is maintained based on that aircraft model's most current set of TOs (25). Ordinarily, that aircraft are configured differently is of little concern; the exception is during exercises when aircraft from different bases converge at a single location and thus the appropriate maintenance may not be performed.

Finally, the concern exists that other than the most current TOs are used but not for desirable reasons (e.g., tardiness of the mail system, failure to properly insert TO changes, etc).

Nature of TO Changes. In this section an attempt is made to determine how much TO data will need to be distributed throughout Air Force activities on an annual basis. The information will help determine whether the the Defense Data Network can support a telecommunications update plan. Unfortunately, the amount of TO changes done annually in terms of bytes is not readily available, attempting to determine that information is beyond the scope of this project. The following conditions indicate the difficulties inherent in such an endeavor:

1. The G022 system maintains only the number of TO page changes made to Air Force TOs. It does not include any specifications respective of the nature of change to a particular page (25).

2. The Air Force does not maintain a central repository of TO changes. Each of the five Air Logistics Centers maintains paper records of TO changes for their respective weapon systems (28). Obtaining an accurate sample is thus compounded.

3. While some information is maintained at each Air Logistics Center on the nature of an in-house TO change, frequently TO changes are performed by the government contractor. For example, at Ogden Air Logistics Center, around 80 percent of TO changes made on the F-16 are performed by General Dynamics; this figure differs with each system (15).

4. The nature and impact of a change can vary widely. For example, consider the following possible TO changes (15):

a. One word on one page, effectively modifying only that page. In this case, the unrevised reverse side of the *changed page* is also considered a page change;

b. additional text on one page that causes a ripple effect on subsequent pages;

c. a single line-item change to a three-page fold-out table that necessitates the entire table be changed;

d. changes that create new blank pages;

e. a new graphic ranging from covering less than half a page to a complete page;

f. a 300-page change with 60 graphics (resulting from a system modification).

This variety of TO changes, and the lack of a readily available source to determine the quantity of data involved in them makes estimating the quantity of revision in a TO change difficult and likely inaccurate.

Amount of Changes Yearly. As stated earlier, there are approximately 20 million pages of TOs, and about 2.3 million pages are modified every year. While about 10 percent of the inventory's pages are changed, certainly not all the text of a given page is revised as a result. Changing one word on a page requires the entire page to be replaced, while adding an additional lengthy paragraph may have a ripple effect, impacting several pages.

Graphical Versus Textual Changes. It is only with some hesitation that experts in the field venture a guess on the proportion of TO pages that contain graphics versus text. This inexact knowledge, however, may provide further insight on TO changes. Though various sources' estimations differ, 30 percent of all Air Force TO changes are modifications to graphics, the balance to text. Of that 30 percent, 50 percent of the changes are due to modifications of text in the graphics (28).

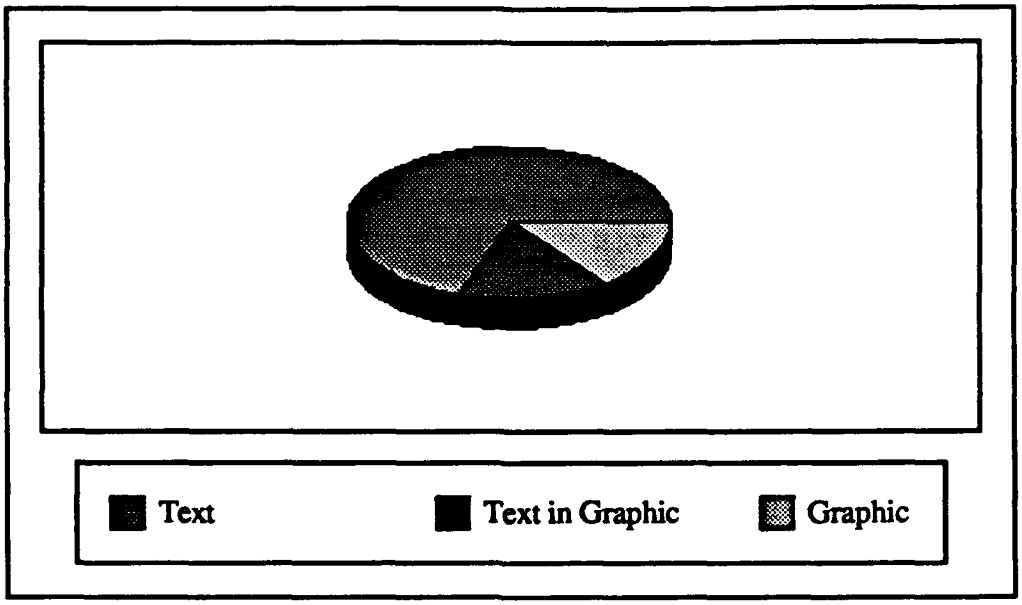

Figure 3. Text vs. Graphic Change in TOs

Fluctuation of Changes. While fluctuation in the frequency with which TO changes are forwarded to bases does not help in determining TO change quantity, it may impact the media used to transmit it. (What is the largest amount of data that must be transmitted over a given period of time? Can the telecommunications network absorb this amount of data?) Experts in the field claim that the flow of TO changes is fairly regular with no way to forecast upcoming increases (28). There is a minor reduction near the end of the fiscal year (as support personnel go on vacation) (15).

Total Mbytes Transmitted Yearly. Attempting to make an accurate guess here is difficult at best. However, an estimate may provide some basis from which to make further decisions. Two methods can be used. Both approaches employ a weapon system TO package as a pattern on which to base typical TO changes (Air Force-wide) in the future. The B-2 bomber will have a TO set which is sufficiently analogous to other digitized weapon system TOs for this purpose (8). Although TO documentation on this weapon system is in its infancy, it provides the best, in not only, example.

The first approach is based on the fact that every year approximately 10 percent of all TO pages are changed. Therefore, if the approximate total size of the sample aircraft can be determined, this data can be used to estimate the amount of TO changes transmitted (8). This information is presented in Table 2.

Table 2. TO Change Quantity Based on B-2 TO Set

TO Set	Number of Pages	Storage in Gbytes	Annual TO Changes in Gbytes
B-2 Weapon System	700,000	14	
Air Force-wide	20,000,000	400	40

An alternative method is to determine the typical size of TO textual and graphical *pages* (not an actual change), and then extrapolate these figures to approximate a total annual quantity. This is done in Table 3. The average Kbytes per page and percentage of graphical versus textual data are based on the B-2 (45). It is assumed that not all of each page is changed.

Table 3. TO Partial Page Change Based on B-2 TO Set

Page Type	Average Kbytes per page	Percent of page changed	Percent of change this type	Average Kbytes per page change	Gbyte changes per year (times 2.3 million pages)
Graphic	50.00	0.75	0.40	15.00	
Text	6.00	0.45	0.60	1.62	
Total	56.00			16.62	**38.23**

In determining the TO total in Table 3, only a portion of textual or graphical (since the entire page may not be consumed by the figure) information on a page will change. This is reflected in the "Percent of page changed" column. Interestingly, if we assume that any change to a page requires that the entire page be replaced, as is inherent in Table 2, the following results as indicated in Table 4.

Table 4. TO Complete Page Change Based on B-2 TO Set

Page Type	Average Kbytes per page	Percent of page changed	Percent of change this type	Average Kbytes per page change	Gbyte changes per year (times 2.3 million pages)
Graphic	50.00	1.00	0.40	20.00	
Text	6.00	1.00	0.60	3.60	
Total	56.00			23.60	**54.28**

This illustrates, albeit roughly, the savings of transmitting solely the portion of the page that needs to be corrected. Table 2 does not account for the blank pages and ripple effect present in the 10 percent of TO page changes. Table 3 does (in a crude way) include this factor. Still, as the numbers are relatively close, an approximate average 39 Gigabytes seems to be a reasonable estimate.

Before concluding this discussion, it is essential to note that new weapon systems may require, on average, that more than 10 percent of the total number of TO pages be changed every year. Certainly, within the first few years the TO change rate will be substantially higher. This increased change rate results because new weapon systems have many "bugs," and because of the nature of the particular aircraft. For example, the B-2 is a "software aircraft" and software changes are more dramatic than traditional hardware changes (45). However, as the B-2 TO set is but a small fraction of the entire Air Force TO inventory, and the nature of software changes (whether these physical changes are performed at or even forwarded to base level) may be unlike traditional hardware-oriented changes, this report uses the 10 percent TO change rate.

Air Force Technical Order Management System

JUSTIS Mission.

> It is the Air Force's objective to reach a 'near paperless' technical order operation—taking full advantage of the automation advances afforded by evolving computer capabilities, and curtailing our reliance on paper products in favor of electronic media. (11:2)

This is only a minor fraction of the JUSTIS mission, but is related to this paper. The management of the Air Force Technical Order System further includes researching and adopting new techniques and technology for technical data format and presentation and distribution procedures (11:3). To this end, the Air Force Technical Order Management System was developed in 1987. Because of the recency with which JUSTIS was chartered, there are

many organizational policies not yet fully determined. Of course, one aspect is the means by which JUSTIS will eventually distribute changes in the 'near paperless' Air Force.

JUSTIS Structure.

Information. The design of JUSTIS is structured around the need to handle different types of information. The system which controls the information is the automated data system (ADS). Under the ADS, information is divided into three domains: 1) operational data; 2) decision support data; and 3) publications. Operational data are associated with recurring activities and are used in fulfilling *operational* requirements. It is information created, retrieved, updated, and distributed on a daily basis in order to support TO users (5:3-4). The information on an AFTO Form 22, TO Change Request Form, falls into this category.

Decision support data are used to manage the TO system; for example, the number of TOs distributed in some arena or a performance assessment. Examples of forms used to record this type of information are the Consolidated Technical Order Improvement Report Status (A-G022C-3JA-D9-MD9) and the Summary of technical Order-Time Compliance Totals by ALC (A-G022C-2PG-D9-2D9).

Finally, publications data include actual technical manuals, regulations, commercial manuals, and other documents which include text, graphics, tables, and pictures. The technical manuals are handled by the JUSTIS in three basic forms: 1) Type A, paper TOs; 2) page-oriented digital TOs; and 3) nonpage-oriented digital TOs, as discussed above. The JUSTIS infrastructure is designed to be implemented in three tiers, with each tier using some or all the different types of information.

TO Distribution. The JUSTIS plan is that by the mid-1990s, local area networks (LANs) will be employed at base level to distribute TOs from a central database at base level. Users will access TOs via handheld portable computers or paper copies published locally (37). The LAN will be used also to submit TO Change Request Forms.

To forward future TO Change Request Forms, users at base level will key a requested change into the LAN. The data will be electronically forwarded to the ALC through appropriate channels for review and approval. Approved changes will be periodically distributed to the user, possibly on write-once read-many (WORM) optical disks to update the local database. The initial time savings will be at the ALC. The information will not need to be keyed into a computer before it is sent to the GPO since the user performs this task. However, the bottleneck will remain at this point.

IV. Technical Order Transmission

Transmission Definition

This section introduces those topics concerned with transmitting digitized TO data from origin to destination, including origin and destination locales, security, and error detection.

TO Transmission Requirements

Locations. All 50 states are included as destinations of "telecommunicated" TOs in this study. Limiting the destinations to the U.S. ensures the scope of this paper is manageable by the author. A telecommunications network must be able to transmit large quantities of information on a regular basis to each locale. Determining the number of Air Force installations is somewhat difficult. Including major, minor and support; active, Air National Guard, and Air Force Reserve CONUS installations, there are some 1004 that may require some type of TO support (31).

Text and Graphics. The telecommunication system must be able to send text and all types of graphics which are included in TOs (e.g., pictures, tables, figures, etc.), regardless of the format.

TO figures are stored both as vector and raster graphics. Vector graphics are mathematical expressions which describe the shape of an object. This method of storing graphical information permits more detailed illustrations and scaling of images. Raster graphics, which consume about the same amount of storage space, record information based on a grid system. The intersections of the grid are close enough that by darkening appropriate coordinate (or pixel), an illustration can be represented. The raster graphical representation approach offers sufficient detail for user understanding (25), but lacks the ability to be

effectively scaled. Both methods will be employed at base level using the Computer Graphics Metafile (CGM) graphical storage method per MIL-M28001A (8; 37).

Security. Security is defined as a delaying tactic intended to prevent unauthorized access to a system (43:401). While less than 1 percent of TOs are classified (1:6-1), they are all considered at least sensitive information and require appropriate security measures. The protection must provide privacy (secrecy) in that unauthorized individuals are unable to interpret data to which they are are not entitled access. Further, the measures must assure authenticity (integrity): the message sent has not been tampered with and is identical to the message received. These measures are provided at the origin, during transmission, and at the destination (discussed under Chapter V).

Error Detection. It is imperative that transmitted TO data be received as nearly identical to the original as possible. Measures must be taken to ensure data reliability: that the information sent is identical to that received. Errors are the result of data becoming unintentionally scrambled during transmission. Errors differ from authenticity in that the latter problem is intentional. Errors that are undetected will appear unintelligible to the user.

Defense Data Network Suitability

The Defense Data Network is composed of several networks. This study is concerned with the military operational communications network (MILNET).

Defense Data Network Protocols. The Defense Data Network uses Transmission Control Protocol (TCP) and Internet Protocol (IP). TCP is a highly reliable host-to-host protocol between source host computers (typically called just "hosts") in a packet-switched computer-communication network (40:1). It is to be the basis for a standard for DoD-wide inter-process communication protocol. IP "provides a way for the TCP to send and receive variable-length segments of information enclosed in Internet datagram 'envelopes' " (40:2).

There are two primary ways to distribute information across the Defense Data Network: File Transfer Protocol (FTP) and Simple Mail Transfer Protocol (SMTP).

File Transfer Protocol.

> File transfer protocol (FTP) "makes it possible to move a file from one computer to another, even if each computer has a different operating system and file storage format. Files may be data, programs, text—anything that can be stored" (9: 31).

FTP permits, and is primarily suited for, interactive access to foreign hosts. It is not designed as a mailing system; however, software such as RDIST exists that can be used in a like manner. RDIST, designed at Berkeley, is used at a master site to automatically copy files to remote locations using FTP.

Simple Mail Transfer Protocol. SMTP is designed for sending electronic mail and therefore is not interactive. It tends to be more secure than FTP and easily incorporates data encryption. SMTP is designed to easily send electronic information to one or a batch of people, but supports transmission of only ASCII characters 32 - 125. This subset of the ASCII code include all upper and lower case letters, numbers 0 through 9, a space, punctuation marks, and about a dozen other symbols found on a typewriter keyboard. Files containing non-ASCII data can be transmitted using SMTP through software conversion programs. For instance, UUENCODE and UUDECODE are two commonly-found programs which transform binary code into ASCII text and from ASCII text to binary, respectively (21; 35). The encoding process approximately doubles the size of the file.

Defense Data Network Distribution. Currently, as indicated above, most TOs are distributed on paper and are from Government Printing Offices using address labels generated by the G022 data base. Interim TOs, however, are the only TOs not currently distributed on paper, but in fact are distributed over AUTODIN (25). AUTODIN is used because the transmission can be encrypted and automated. The message is sent from the base communications center supporting the activity sending the change. Addressing here is performed using an Address Indicator Group. The processes are similar in that both the

G022 and Defense Data Network maintain a data base of activities to which TOs are forwarded.

Address lists (produced by the G022) can be built with SMTP to automate delivery of messages over MILNET.

Defense Data Network Cost. It was only recently that the Defense Data Network began charging customers. As such, current pricing policies may likely change. The cost of sending data is based on kilo packets (128,000 bits) regardless of the number of destinations to which a message is sent. Levels indicate the precedence a message carries, indicating how quickly it should arrive. Level four receives the highest priority. Table 5 breaks out how Defense Data Network customers are charged.

Table 5. Usage Cost of DDN (24)

Peak Hours 0800 - 1700 local Weekdays	**Off Hours** 1700 - 0800 local Weekdays and all weekend	
	Level	
$1.30/kilopacket	1.	$1.01/kilopacket
	2.	3.00
	3.	4.00
	4.	5.00

Connect/Dial-up Charge

7.5¢/minute

Defense Data Network Reliability. There are two concerns regarding reliability: 1) packet corruption, and 2) whether the necessary telecommunications links/circuits are operating in order to pass the packet. Packet corruption regards whether the information in

a message arrives at its destination without any errors. Under FTP and SMTP, the incidence of corruption is virtually zero (35).

The second problem, circuit availability, is resolved differently with each protocol. Under FTP, if no circuit to a desired location is available, the user is unable to (interactively) connect with that host. With SMTP, local hosts are programmed to send the mail transmission at a determined frequency and for a determined duration, until the message is either transmitted and acknowledged or transmission is never completed and the sender is notified (21).

Defense Data Network Security. No transmissions over the MILNET are provided any measure of security (e.g., encryption). However, within three years, all MILNET trunks will possess the necessary equipment to send encrypted messages, up to the classification of secret (32). This is to say that the Internet, or network trunks, will be encrypted, but not necessarily the host computer to which the system is connected. Upon implementation, sensitive but not classified information may be transmitted.

Blacker, an encryption device, would resolve the problem of transmitting classified information over MILNET. Blacker permits the transmission of classified data by encrypting data at the host before it is sent onto the Internet (32). No implementation date for Blacker has been approved.

V. Unit-level Storage

Define Unit-Level Storage

This section addresses all aspects of storing and managing TOs once they have been received over Defense Data Network. Areas include security, available storage media, configuration control, JUSTIS base-level storage requirements and cost.

Security Concerns

Physical. The physical security requirements pertain only after the TOs have been downloaded from the Defense Data Network and prior to distribution on what will more than likely be a Local Area Network. This pertains to getting the data from the base communications center into the TO data base if it is not collocated.

Available Storage Mediums

Introduction. This section reviews literature regarding optical disk storage. Included is the magneto-optic disk (MOD); write-once, read-many-times (WORM) disk; and to a lesser extent the Compact Disk read-only memory (CD-ROM). All three disks perform as secondary storage media for computers, functioning in the same way as a conventional magnetic storage media like a floppy or Winchester drive. Unlike conventional media, these disks use laser technology to read and/or record data. They vary in the number of read-erase cycles that they support. The focus of this paper is primarily on MODs and WORMs.

Until recently, the production of data has outpaced the ability to efficiently store it. The advent of the CD-ROM, WORM disk, and the MOD has provided a medium to more efficiently store data in quantities than ever before. This review surveys articles in periodicals published since 1985. The areas of optical disk technology covered include the

following: 1) mechanics; 2) durability; 3) storage; 4) cost; 5) miscellaneous advantages; 6) applications; and 7) predictions.

Mechanics. Optical disks are similar in appearance and resemble a compact audio disk as used in home stereo equipment. They are manufactured in 3-1/2-inch, 5-1/4-inch, 12-inch, and 14-inch diameter sizes (6:13). The optical disk player, the unit which reads and/or records data, houses a laser that focuses a beam of light on a 0.6 micron-wide track on the disk. The track is like that on a phonograph, spiralling from the center. With the CD-ROM and WORM, the disk spins at 500 r.p.m. The light produced by the laser is strongly reflected off shiny, "unscathed" lands and scattered by pits etched into the metallic disk surface. With any digital computer, data are recorded and manipulated as digits--that is, 1s and 0s.. On the CD-ROM, it is the transition from land-to-pit or pit-to-land that produces the 1 digit. The path in between generates a string of 0s (16:67).

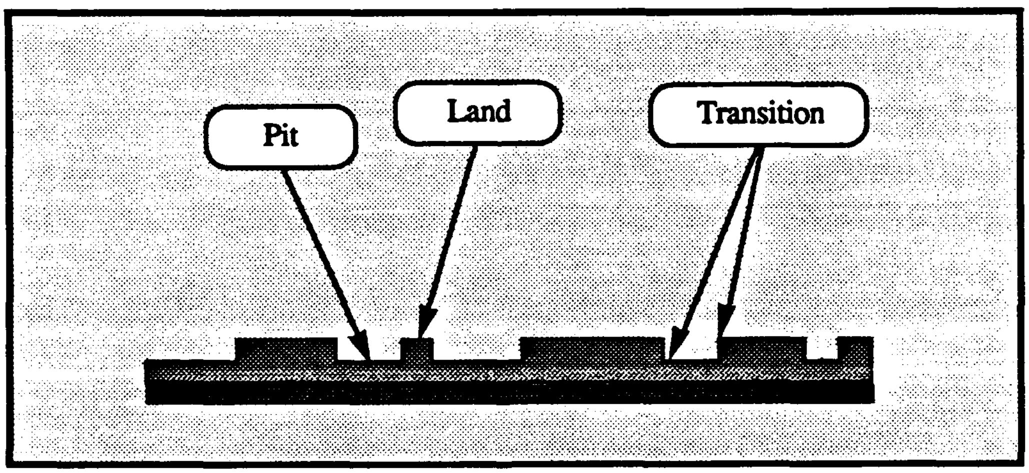

Figure 4. Profile of CD-ROM/WORM

The way a MOD produces digits is by the polarization of the magneto-optic layer. It is best explained by detailing how bits are recorded. A several nanosecond burst of light from an infrared laser is focused on a micrometer spot--a bit--of the disk. The laser burst

produces a 150 degree Celsius temperature which brings the coercive magnetic force required to flip the domain to zero. That is, at this temperature, the ease of reversing the polarization of the bit from north-pole-down to north-pole-up is easiest. Once the bit has reached this temperature, a bias coil near the disk surface flips the polarization. It is this individual spot which is read as either a 1 or a 0 (17:43).

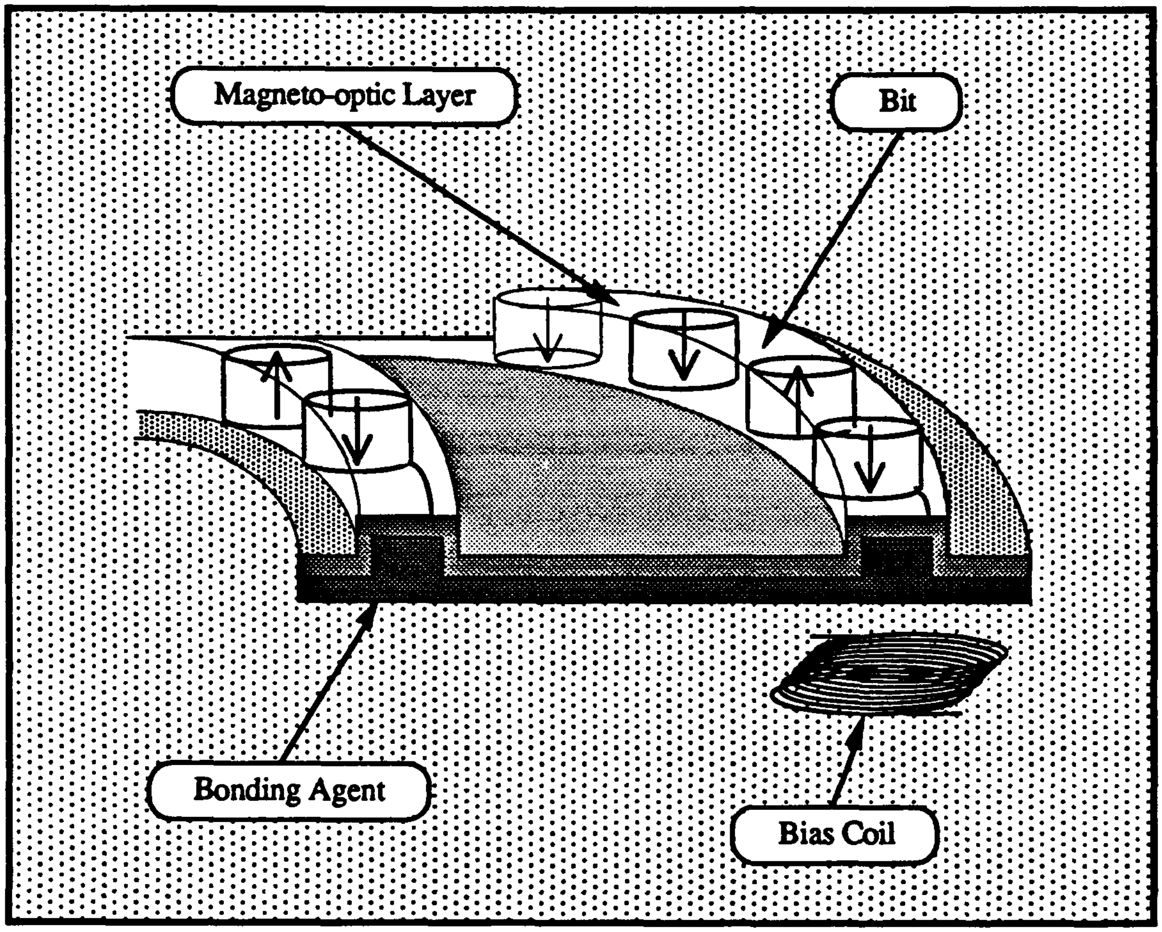

Figure 5. Magneto-Optic Disk Physical Structure

The technology necessary to manufacture "alterable magnetic surfaces" for optical disks was developed in 1981 by 3M, Inc. MODs use rare-earth coatings such as gadolinium terbium iron, terbium iron cobalt, and terbium iron. Once the basic materials were

developed, the hurdle to overcome was increasing the number of times a MOD could be modified. Earlier methods required a localized recording temperature of 600 degrees Celsius to bring the coercive magnetic force to zero. Here, repeated polarization alterations would break the chemicals' bonds (17:43).

Passing the information from the media to the computer has also undergone improvements. This is a problem which all three types of disk have suffered because the same type of mechanism is used in each of the drives. First generation drives had slow **access times**, from 40 to 100 milliseconds (ms)--double that of Winchester drives. Improvements in second generation drives with access times of 20 ms have been demonstrated. **Data transfer** rates of first generation drives are comparable to Winchester drives, ranging from 5 to 10 Mbits per second. Second generation drives may approach 16 to 30 Mbits per second (17:43).

Durability. Though today's magneto-optic disk drives found on the market do not compare favorably in access times to Winchester drives, durability is an area where they currently surpass their counterpart. MODs can undergo at least as many write-erase cycles as a conventional storage--possibly more than 10 million. And they should maintain their integrity for over 10 years, three times as long as conventional storage (17:44).

A recently produced optical disk by ICI Electronics is flexible. It is a high density film which has been dubbed "digital paper." Digital paper has an initial storage life of 15 years and ICI plans to develop its product to last 20 years (14:32).

With any optical disk, light beams are used to read, write, and erase the data. As there are no mechanical heads that touch the material, there are no head crashes as associated with Winchester drives. The magnetic layer is embedded within a 1.2-millimeter layer of glass or plastic that protects the surface from dust, wear and the drive-head (18:168). Special storage precautions are not necessary, a fact which makes the optical disk easily and safely transportable.

Storage. While the physical safety of information offered by MODs, CD-ROM and WORM disks is considerable, the quantity of data that can be stored is of greater benefit. A 5-1/4-inch MOD can store 1000 times the amount of a floppy disk of equal size (17:41). A CD-ROM can store 200,000 pages of text, the equivalent of 1500 floppies (29:72). On a square inch basis, a Winchester drive can carry 43 Mbits while the MOD carries 300 (29:71). The largest optical disk, 14 inches in diameter and produced by Kodak, can store up to 6.8 gigabytes of data. Fourteen-inch optical disk autochangers, called jukeboxes, hold up to one terabyte (or one trillion bytes) of information (6:15). Comprehending the amount of storage a disk can handle might be better understood in other terms. Based on writing one page per second, eight hours a day, five days a week and 48 weeks a year, the following information would be accumulated (18:19):

Table 6. Data Accumulation Over Time

Data Accumulated	**Period of Time**
1 gigabyte	seven weeks
8 gigabytes	one year
26 gigabytes	4 years
1 terabyte	155 years

In terms of personal computers, most will be equipped with the standard 5-1/4-inch disk. It carries 600 Mbytes on two sides; the 3-1/2-inch disk will hold 80 Mbytes (17:41).

Cost. All this opportunity may soon come at a very reasonable price (depending upon one's perspective), and in some cases already does. The digital paper manufactured by ICI Electronic mentioned earlier is not erasable, but at a half-cent per Mbit it is by far the least expensive way to store information. "You can throw it away when you're done with

it, it's that cheap," says Michael Strelitz, marketing director for ICI Electronics (14:32). Mag tapes cost 20 cents per Mbit, 800 Mbyte optical disks cost 25 cents per Mbit, and a medium quality Winchester disk drive costs 10 cents per Mbit (14:32).

The cost of a single-user magneto-optic system runs around $50,000. This type of system would entail, for example, an IBM PC/AT, one or two manually loaded optical disk drives, a high-resolution monitor, a scanner, and a laser writer. At the other end of the spectrum, a networked system for the largest corporation would have a starting cost of approximately $700,000. It would offer about 340 gigabytes of storage, offering centralized data immediately accessible to users (6:14).

One drawback the CD-ROM suffers is recording the information onto it. It is time-consuming and impractical to put daily or weekly publications on CD-ROM. Each master disk costs from $10,000 to $60,000 to produce, estimates Steven K. Sieck, an analyst at Link Resources. Copies cost from $20 to $40 (29:71). However, WORMs and MODs require no master disk since they are "manufactured" within a computer.

Another problem with the new technology is copying information onto a computer for archival and improved accessibility purposes--a topic that is discussed later under applications. Scanning the information into a computer is burdensome and can consume many man-hours to store large quantities of data. The process, scanning and quality control, proves to be "the most time-consuming, expensive, and problem-laden aspect of implementing the optical disk technology" (22:8).

Miscellaneous Advantages. Still, the advantages of the MOD outweigh its disadvantages. It enables the user to access information in seconds that magnetic tape or microfilm would require minutes or even hours to locate. Proximal seeks (where the data is localized in adjacent blocks of information on the disk and the head does not have to be moved--about four Mbytes of data) can be superior. And in "data-logging" applications with WORM disks, data transfer is about the same (18:16).

Since WORM disks never overwrite data, data is never lost and an audit trail or history is maintained. Petrocon Engineering Inc. opted not to use rewritable magneto-optic disks because the company required an unalterable archive file (46:43). MODs are susceptible to accidental erasure or alteration, but it it is almost impossible. A floppy disk, however, could be scrambled by the 600-volt dc power rail on a subway transit system. In the same vein, the problem of magnetic patterns bleeding into adjacent areas--domain-wall migration--is greatly reduced with the MOD (17:42).

Applications. So how will these advantages be applied? There is some argument that the major hurdle to productivity in the office has been the ability to handle the growing quantity of paper (38:29). Optical disk technology will help diminish this obstacle. Imaging, or digitizing, documents onto a computer and subsequently an optical disk centrally stores all data and eliminates or significantly reduces many problems. Problems include waiting for documents, documents out of file, misfiled, in internal mail delivery, and access and privacy problems (38:32). It allows immediate access by multiple users, reduces copying costs, and permits the use of sophisticated databases to file documents (38:30).

The U.S. Postal Service Government Relations Department has implemented a system similar to that described above. The agency receives about 25,000 letters annually (referred from Congress or the White House) that require responses to congressional constituents. Response letters are scanned into a computer and stored on optical disk. (The date of the article and technology indicate WORMs are used.) The system eliminated 200 linear feet of paper files, 100 to 200 working hours a month locating files, and misplaced files (39:43-44).

Several other government agencies considering implementing optical disk technology are in the test phase. As WORM disks make storage of high-resolution images feasible, they offer the possibility of storing images of manuscripts, maps, sheet music, pictures, prints, photographs and architectural drawings (22:1). The National Archives will

conduct a test to store a manuscript collection of 1.5 million Civil War personnel records onto WORM disks (22:8).

A U.S. Patent and Trademark (PTO) pilot system will reduce storage and ease access to files. Currently the PTO stores files in three 11-story buildings. In 1987, the PTO received about six million pages of foreign and domestic patents. Patents are filed using 117,000 different classifications. When a patent is submitted, PTO examiners use manuals to see which classes of technology must be searched for pertinent patents. Despite there being 3.2 copies of each patent on file, seven percent of the time patents are missing from their files. Once images are stored on WORM disks, several images can be retrieved and visually compared against one another simultaneously without any waiting (22:7).

The Army and Air Force have combined a system to replace their respective repository of technical drawings of weaponry and place the information on WORM disks. The material to copy is black-and-white engineering drawings, specifications, and parts lists on aperture cards, microfilm, and hard copy. There are approximately 50 million documents active; each month 4,000 to 5,000 are added. The purpose of the system is to "increase storage and reduce administrative lead time in retrieving and reproducing engineering documents, replace current obsolete systems, and provide continuity of operations" (22:7).

The IRS deals with an estimated 2.5 billion pages of documents each year, generated internally or received as tax returns. Storage, retrieval, transportation, and control exceed $30 million. In 1984, the IRS awarded a $3.7 million contract to Integrated Automation of Almeda, California "to develop a digital imaging system" (22:7).

Finally, regarding government use, the Air Force Office of Special Investigations (AFOSI) is operating a pilot system to maintain files on criminal investigations for narcotics, fraud, and counter-intelligence. Government agencies consult the files upon hiring or clearing personnel. AFOSI archives about 8,000 25- to 30-page files per year, and must keep them for 15 years. The agency went with this storage system because of a need to reduce storage space (22:7).

Outside the government, businesses too have a need for the technology. Large corporations such as telephone companies and utilities maintain huge active files which could justifiably be maintained on optical disk (6:15). A Fortune 500 company may have more than one room the size of a football field for computer backup (17:41). A jukebox of WORM disks could hold the same quantity of information.

"Every major publishing company is experimenting with it [CD-ROM] in some way," says Leon Williams, senior vice-president for systems planning and publishing at McGraw-Hill, Inc. The publishers use them to publish reference material like an encyclopedia, *The Fine Chemical Directory*, or *Books in Print* (29:71).

One of the reasons WORM technology is used more than MOD is that the latter is so young. Says Jerry Braun, marketing manager for Integrated Automation Inc., "Ultimately, we'll go with erasable if the technology comes down in price. Right now, the technology's not there" (46:43). It is not likely that MOD technology will displace WORM. "Most analysts predict that the two technologies will coexist" (46:43).

Predictions. Coexist or not, improvements in MOD technology will be substantial. Engineers predict that over the coming years storage capacity will increase tenfold: 5-1/4-inch disks holding in the neighborhood of 6000 to 7000 Mbytes are foreseeable. And data transfer rates will grow from 5 Mbits per second to 500 (17:45). If nothing else, erasable optical disks could become the dominant computer storage medium of the next decade (29:71). Says consultant Edward S. Rothchild of San Francisco, "Once that happens [that you can sit at your computer with an erasable optical disk], the much greater storage capacity of optical disks ensure that they will eventually replace magnetic disks" (29:71).

Conclusions. Optical disk storage is in its infancy. Progress still needs to be made before MODs can compete with other storage optical storage media, primarily CD-ROM and WORM disks. But the potential of magneto-optic disks is greater than any other computer storage. Because the systems use laser technology, laser-optic media have several advantages over their magnetic cousin. Digital paper is the cheapest storage medium, all

optical technology maintain data integrity longer, and head crashes are no longer a concern. Probably its greatest advantage is the amount of information it holds. Except for digital paper, the cost is still high. Despite the high cost, many government and civilian organizations have implemented the technology or are testing it now. And the results are very promising. Not today, but early next decade optical disk technology will be superior in almost every way to the traditional media now in use. Engineers predict it will store 10 times more data than possible today--that is, an amount 10 times more incomprehensible than it now stores.

JUSTIS Distribution Plan

Local Area Networks. Under JUSTIS, Major Commands are responsible for developing a means of distributing TOs from the central data base to user, such as on the flight line (25). Local Area Networks will probably be employed to perform this. Whatever medium is used to store the TOs must be able to integrate with this system. The method of distributing TO data at base level is beyond the scope of this paper.

VI. *Evaluation*

Introduction

The purpose of this chapter is to describe the author's proposed model, method of testing, and results obtained. The evaluation will hopefully discover any weaknesses in the model and, through rectifying these deficiencies, improve the result. The model is included at Appendix B. Expert responses are attached at Appendix C.

Proposed Model

This section is divided into two sections: Telecommunications and distribution. These two aspects include the entire TO update transmission process.

In reading this section, consider that the Air Force plans to implement the distribution of digital TOs in the "mid-1990s" (4:2-1). Many new developments are scheduled to be completed in the JUSTIS arena before the model would be implemented. For instance, base level Air Force activities are unable to handle digitized TOs. LANs at each main operating base must be installed to handle digitized TOs. Also, ongoing changes to MILNET are scheduled to be completed at approximately the same time as the proposed model would be implemented. Implementation of the proposed model *could not occur* until some of the aforementioned prerequisites are met.

Telecommunications. The research indicates that there are two potential ways to transmit TOs throughout the Air Force. Unfortunately neither is ideally suited to this need, and therefore some adaptations must be made. FTP is not designed specifically for the automated distribution of data to activities throughout installations in the fifty states. SMTP is designed to transmit only a limited set of ASCII characters. While FTP does possess the capability of transmitting any digital data, overcoming the distribution problem appears

larger than overcoming the ASCII limitation of SMTP. Primarily for this reason, and the additional security that will be offered under SMTP, the model will employ SMTP.

Text and Graphics. Although SMTP uses only a limited character set, there are conversion routines (UUENCODE and UUDECODE) which convert a binary file to an ASCII file and vice versa. The converted file, however, is approximately twice the size of the original file.

Locations. Transmission would be from the ALC or SPO responsible for the weapon system. Once a TO change has been approved, the data would be converted into ASCII code and distributed to the appropriate locations using SMTP. Address Indicator Groups would be built from existing information on the G022.

Because SMTP is automated, the host would notify the sender whether each recipient received the TO update. The sender determines the frequency and duration at which SMTP attempts to complete message delivery.

Security. Within three years, MILNET trunks will be encrypted. This will permit transmitting TOs up to and including the classification of secret. Further, keys will be available under SMTP to ensure authenticity.

Distribution. Once a base receives the TO update, the ASCII file must be converted back into a binary format using UUDECODE. The message could be downloaded onto a computer connected to MILNET and with access to the LAN where the conversion process would occur. Upon conversion completion, the updates would be applied to the TO data base. This data base process will be supported by system software; detailed analysis is beyond the scope of this study.

Storage Medium. This transmission procedure requires an optical medium that can be updated locally—either WORMS or MODs. In determining which medium to select, two considerations must be addressed: 1) Access speed, and 2) audit trail.

Access speed is not of major concern since user access of the TO data base will not be highly interactive, as would it be with transaction processing. WORMs are slower in

access speed than MODs, a problem that will compound itself over a period of time. Moreover, since MODs are rewritable, disks can be defragmented periodically, making access speed comparable to CD-ROM. Defragmenting a disk speeds up access time be rearranging data on the disk into a more efficient order. The limitation of MODs is that they do not maintain an audit trail.

Precisely because WORMs are not rewritable, every transaction performed on a disk, authorized or otherwise, is recorded. However, the requirement for an audit trail, which is not maintained by MODs, can be supported by computer software. This is included in the functional description. Therefore, MODs will be employed as the storage media.

Method of Testing

The following questions were designed to detect any problems that would have to be overcome in order to implement the model, as well as to find benenfits that might arise through its use.

Questions.

1. Are there any transmission problems that this TO update system will encounter using SMTP on MILNET (e.g., amount of traffic on MILNET, etc.)? Possibly in the future?

2. What effects would the conversion of binary to ASCII and back have in transmitting or storing TO data?

3. Will the usage of rewritable optical disk storage fulfill JUSTIS system requirements? If not, why?

4. Are there policies or procedures defined under the JUSTIS Functional Description which make this model impractical?

5. What do you feel are the best and worst features of this model? Are there circumstances when this distribution method would be particularly useful?

6. Would you favor adoption of such a model? Why? If not, what changes would you want before you would accept the model?

7. May I contact you regarding your responses? Yes No

8. May I cite your name in my thesis? Yes No

9. Please feel free to include any additional comments.

Expert Selection. The physical aspects of the model (i.e. telecommunications and storage medium) are easily verified. It is the procedural requirements established by JUSTIS which are most difficult to adhere to. In this light, four JUSTIS experts will evaluate the procedural and technical feasibility of the model. Also, two experts from the AFIT Engineering School will eveluate the telecommunications aspect.

Experts' Responses and Analysis

The actual replies of the experts are found at Appendix E and are analyzed below.

Question One. Are there any transmission problems that this TO update system will encounter using SMTP on MILNET (e.g., amount of traffic on MILNET, etc.)? Possibly in the future?

Transmission problems may exist for the model based on MILNET limitations (27; 36). In fact, one expert feels it may be necessary to contract with private organizations because "government networks will be so poor" (36). Another concurs, specifying the problem is likely to occur in the "northeast quadrant of the USA" because of the degradation of telecommunications lines (27). Despite this, currently safety TOs and supplements are planned to be sent over DDN and DCTN; this is estimated to amount to one percent of all TOs (7). Finally, two experts point up that MILNET may be unable to satisfactorily transfer large files (19; 26). Here, while the amount sent during the course of the year will be "large," individual files could be small (less than six kilobytes).

Question Two. What effects would the conversion of binary to ASCII and back have in transmitting or storing TO data?

The most significant point drawn from the experts is that TO text will be stored in ASCII (7; 36) at the ALC according to MIL-STD 1840. In this case, the estimate of the amount of GBytes of TO change data to be sent over MILNET will be reduced, probably

several GBytes, as well as the time to convert to binary. Another expert expresses a question regarding the length of time to convert the files.

Question Three. Will the usage of rewritable optical disk storage fulfill JUSTIS system requirements? If not, why?

There exists concern whether MOD technology is suitable because of the capability to detect corruption, in all forms, to the data. *If* this problem can be resolved, erasable optical media "COULD" satisfy JUSTIS requirements (36). Another expert claims erasable optical media will not fulfill JUSTIS requirements, only citing current plans but not stating why this is so. Another concern is the configuration control that erasable optical media might cause, primarily at Tier 4 (20). Finally, one expert points out that it is simply too early to determine what media will be appropriate as it will be late in the decade that JUSTIS reaches Full Operating Capability (27).

Question Four. Are there policies or procedures defined under the JUSTIS Functional Description which make this model impractical?

The experts express no significant comments here.

Question Five. What do you feel are the best and worst features of this model? Are there circumstances when this distribution method would be particularly useful?

Two of the experts commented here, pointing out that emergency actions (i.e. TCTOs) could receive quicker action under this plan (20), if it were incorporated today (27).

Question Six. Would you favor adoption of such a model? Why? If not, what changes would you want before you would accept the model?

One expert states, provided "the model is well enough documented to provide for a framework on which costing and traffic loading can be directly tied to technical aspects of the MILNET and related telecommunications capabilities, then I could use the model" (36). Other concerns here include sending changes overseas, providing interface with users, and how the user will know that his TO data is current.

Question Nine. Please feel free to include any additional comments.

The primary point that surfaced here regards making assumptions in the model (e.g. using MOD as the storage media) or not making assumptions in the model (e.g. having to include infrastructure policy on how information is passed to and from the different tiers). These points, while valid in their content, are largely out of the scope of the research project.

VII. Recommendations and Conclusions

Author's Conclusions and Recommendations

Nature of TO Changes. The Air Force has to date not performed a study of the nature of TO changes. The most definitive answer the USAF has regarding this is that two millions pages of TOs are changed every year. Two experts points out that the author's estimate "is every bit as good as any others" (36). As explored earlier in this paper, the amount of data may be in the range of 39 Gbytes, but this figure is likely to be well over the actual amount. The significance here is that JUSTIS will decide upon some hardware system for forwarding TOs; but without any good idea as to how much TO data is changed on an annual (or other) basis, JUSTIS may likely not select the optimum system. As to how much data is actually changed, a study in and of itself could be done here.

Transmission. Since several experts pointed out the limitations of MILNET, more study is needed here. There is no indication that the method of distribution is unfeasible, only that a private organization might have to support TO transmissions. Some TOs will, in point of fact, be distributed over DDN.

Text and Graphics. One expert notes in question two that text will be stored in ASCII according to MIL-STD 1840 is of benefit to this model (7; 36). The significance is that textual TO changes will not be converted into binary in order to forward them over MILNET, saving time and money.

Storage. In the responses one expert notes that it may still be too early to decide upon a storage medium. The most significant concern seems to be whether an erasable medium can be adequately protected. An analogy is made to the B-2 which will be likely using a nine-track tape (45). Both can be erased, though the MOD is much more difficult to inadvertently change; and only the MOD is randomly accessible. So while the tape may provide for the needs for the B-2, JUSTIS experts are hesitant to suggest that an erasable

medium will do so for the rest of the Air Force. One anonymous source remarked to the author that the "TO mafia" is not particularly open to innovation.

Conclusions. The author's personal opinion on the JUSTIS program is that it is so overwhelmingly large with so many different interests (and chiefs), that determining an optimum TO update system will be difficult at best. Even with computer and telecommunications technology being a daily and essential part of our lives (albeit unwittingly to many), there is a predominant uneasiness with both. This is, of course, especially the case with those not intimately familiar with its capabilities: this happens to be a large part of the number of interests involved in the JUSTIS arena. The reader is cautioned not to assume that the author is suggesting his model is optimum—it suffers from shortcomings, some of which may be unresolvable. However, working with a variety of different individuals involved in the world of TOs, there is undeniable hesitation to employ leading technology.

Further Research.

1. Determine what the nature of TO changes are like. JUSTIS will eventually implement this type of data tracking, but today these important questions cannot be adequately answered:

   a. How many of the 2.3 million TO page changes are due to revisions, new graphics, blank pages?

   b. How much of the change is textual versus graphical?

   c. In changes to graphics, how often is the change a textual change?

These answers might lead to a variety of different ways of resolving the TO change problem.

2. Determine what political issues and actors exist (e.g. the publishing lobby) in the JUSTIS arena. This information would enable managers to reach an optimal decision while dealing with external special interest pressure.

3. Determine the difficulty in protecting erasable media at base level from unauthorized alteration.

Final Comment. There is reason to believe that the proposed model in this report would be of value under certain circumstances in the USAF. It is simple, requires minimal effort to implement, probably has wide ranging use, and is arguably reliable. To its detriment, it is an unusual concept to a great many, requiring the decision to employ computer and telecommunications technology by individuals who have spent most of their lives without such things. The impact is a common concern in the implementation of computer systems. One must suspect with time and personnel change, such possibilities will become technically more practical and intellectually more acceptable.

Appendix A: Model Cover Letter

AFIT/LSG (Capt Fox, 5-8989) 16 Jul 90

Technical Order Update Model

1. As part of my thesis, I've developed a model to determine the viability of distributing technical order (TO) changes over a telecommunications network. The model is a simple, straightforward description of my answer to updating TO changes. In order to determine any shortcomings in the model, I've asked you to review the model and answer the attached questions. I've provided some background information below.

2. The Joint Uniform Service Technical Information System (JUSTIS) was chartered to improve the way in which the Air Force manages its TOs. Because of the involvement that TOs have in the way the Air Force does business and over 20 million TOs that must be managed (with 2.3 million page changes annually), the effectiveness of the technical order system significantly impacts military readiness and the Air Force budget. However, much of the current system does not meet todays' complex Air Force needs.

3. TOs serve as the primary educational and operational tools supporting the Air Force-wide maintenance program. Air Force systems and equipment, with some exceptions, are operated and maintained according to procedures described in the TOs. The model pertains only to weapon systems.

4. My thesis investigates the ramifications of transmitting TO changes over the Digital Defense Network, taking into consideration cost, security, data integrity and configuration control. Please keep these points in mind when answering the attached questions. Though some of the questions may not be within your particular field of expertise, I will appreciate any feedback you have. Please forward them to me NLT 23 Jul 90. I can be contacted at the number above or by e-mail (CFOX@BLACKBIRD.AFIT.AF.MIL) if you have any questions or comments. Thanks for your support.

CHARLES W. FOX, Capt, USAF
Graduate Student, School of Systems and Logistics
Air Force Institute of Technology

2 Atch
1. TO Change Model
2. TO Model Questions

Appendix B: Technical Order Change Model

In evaluating this model, consider that the Air Force plans to implement the distribution of digital TOs (e.g. on optical disk) in the mid-1990s. Some developments in the JUSTIS arena will occur before this happens. For instance, most Air Force activities at base level are currently unable to access digitized TOs. LANs at base level must be installed for these TOs to be used. Also, ongoing changes to MILNET that are part of the model are scheduled to be completed within the next several years.

Model

Transmitting Changes to Main Operating Bases

- TO updates will be transmitted over MILNET using Simple Mail Transfer Protocol (SMTP). Message traffic costs $1.01 per kilo packet (128 bits) during off-peak hours.

- SMTP reliably carries only a portion of the ASCII character set. Therefore, TO update files will be converted from binary into ASCII and back using a common, conversion program.

    - TO update files will be converted to ASCII at ALC/SPO level using UUENCODE, for example, and returned to binary at base level using UUDECODE. This process approximately doubles the size of the original file.

    - TO update transmission will be from the responsible ALC/SPO. Address groups will be built (from already defined lists) and maintained on the sender's host computer.

- Approximately 78 gigabytes of data (after conversion) will be distributed annually (6.5 gigabytes monthly) to USAF main operating bases in the 50 states.

- TO updates will be sent during off-peak hours (1700-0800 local) and arrive no later than the morning following distribution from the SPO/ALC. The updates would be converted back to binary code and integrated into the local data base the day of receipt.

- Within three years all MILNET trunks will be encrypted. This will permit transmitting TOs up to and including the classification of secret. Further, keys will be available in the future under SMTP to ensure authenticity.

At the Main Operating Bases

- Once a base receives the TO update, the TO must be converted back to binary. The message could be downloaded onto a computer connected to MILNET and with access to the LAN where the conversion process would occur. Upon conversion completion, the updates would be applied to the TO data base.

- Erasable Magneto-Optic Disks (MOD) will be employed as the storage media for TOs. MODs function similarly to traditional computer hard drives. They can be completely overwritten and updated. One 14-inch carries up to one terabyte (one trillion bytes) of information, more than enough space at any one base (the digitized B-2 TOs will consume about 14 gigabytes of space).

- Access time for second generation MOD drives, not yet on the market, are comparable to Winchester drives.

- Security (physical, audit trails, etc.) at base level is prescribed under JUSTIS documentation and will be provided by system software and policy. Included in the security will be access restrictions and software to record the identity of individuals who have accessed this data.

Appendix C: Model Questions

Name ______________________________________

Duty Title __________________________________

Duty Phone ______________

1. Are there any transmission problems that this TO update system will encounter using SMTP on MILNET (e.g., amount of traffic on MILNET, etc.)? Possibly in the future?

2. What effects would the conversion of binary to ASCII and back have in transmitting or storing TO data?

3. Will the usage of rewritable optical disk storage fulfill JUSTIS system requirements? If not, why?

4. Are there policies or procedures defined under the JUSTIS Functional Description which make this model impractical?

5. What do you feel are the best and worst features of this model? Are there circumstances when this distribution method would be particularly useful?

6. Would you favor adoption of such a model? Why? If not, what changes would you want before you would accept the model?

7. May I contact you regarding your responses? Yes No

8. May I cite your name in my thesis? Yes No

9. Please feel free to include any additional comments.

Appendix D: Glossary

AFTOMS	Air Force Technical Order Management System. The SPO responsible for managing TOs prior to JUSTIS.
ASCII	American [National] Standard Code for Information Interchange. A seven-bit-plus parity code for achieving compatibility among data services, and consisting of 96 displayed upper- and lower-case characters and 32 non-displayed control codes .
AUTODIN	Automated Digital Information Network.
CALS	Computer-aided Acquisition and Logistics Support.
CGM	Computer Graphics Metafile. A method for storing computer graphics per MIL-M-28001A
CSPP	Communications-Computer System Program Plan.
DCTN	Defense Commercial Telecommunications Network.
DDN	Defense Data Network. A telecommunications network managed by the Defense Communications Agency for the primary purpose of distributing unclassified documents.
Frame store	"A frame store is capable of holding a monochrome or coloured image in the form of several hundred thousand picture elements (pixel) when the store is scanned by suitable electronic circuitry, the resulting digital signal can be converted into an analog form and connected to a video monitor which displays the stored image" (44:43).
FTP	File Transfer Protocol. Designed to permit transfer of data files over a network irrespective of the source or destination host computers (e.g., the Defense Data Network).
GPO	Government Printing Office. The office that negotiates and oversees government contracts for printing (1:1-8).
IP	Internet Protocol. An intermediate protocol used in the Defense Data Network.
JUSTIS	Joint Uniform Service Technical Information System. The SPO responsible for managing TOs in conjunction with the Army and Navy. It originated from AFTOMS.
Kilo packet	One thousand packets.
LAN	Local Area Network.

Mbit Megabit. One million bits.

Packet One hundred twenty-eight bits.

Pixel "A pixel is one picture element within a computer display system. In the case of a frame store, there might be three memory positions which store the primary video colours for each pixel position on a colour monitor" (44:88).

Raster "Describes a cathode-ray tube in which a pattern of scanning lines divides the display area into addressable points" (23:76). (See raster graphics.)

Raster graphics "Raster graphics: computer graphics in which display images, composed of an array of picture elements arranged in rows and columns are generated on a display device" (41).

SMTP Simple Mail Transfer Protocol. A Defense Data Network protocol designed to automatically transfer electronic mail and consisting of a portion of the ASCII character set.

TCTO Time Compliance Technical Order. "The authorized method of directing and providing instructions for modifying equipment and initially establishing or performing a one-time inspection" (1:1-9).

TODO Technical Order Distribution Office

Trunk A link; the circuit established between two adjacent nodes (43:539). That part of the Defense Data Network which includes the transmission media and nodes in a link.

Vectors graphics "Vector graphics encompasses the area of computer graphics dedicated to processing and displaying images composed of lines (vectors), as opposed to rastor graphics which creates pictures on a pixel basis and employs television video technology for display purposes" (44: 119).

O'Bleness, Ralph, Project Engineer (System Engineer and Technical Assistant SCTA, contractor working for Joint Uniform Service Technical Information System System Project Office).

1. Yes; transmission problems under the current networks will abound if DCA and the rest of the community don't adequately fund and manage the ongoing efforts to upgrade MILNET, use FTS, etc. I am p^rsonally very, very concerned that the government networks will be so poor that the JUSTIS program will have to go to private data networks.

2. Note my comments [below] on the effects of the conversion process. Given those, the effects would be negligible for the "repository" functions in JUSTIS. However, the doubling of files-in-transit would certainly concern the comm systems folks.

3. Use of rewritable optical media COULD satisfy JUSTIS requirements if a means of ensuring totally reliable detection of corruption in all forms can be obtained. I do not see that in the immediate technological breakthrough arena.

4. No. And I don't anticipate the changes forthcoming in the FD to have any policies or procedures requirements that will make the model impractical.

5. See comments [below].

6. If the model is well enough documented to provide for a framework on which costing and traffic loading can be directly tied to technical aspects of the MILNET and related telecommunications capabilities, then I could use the model. Documentation of capabilities and plans should be complete enough that we can quote them directly.

7. Sure, contact me anytime.

8. No; I'm a contractor working in the SPO. Such a by-name quote wouldn't do. [Note: The author later discussed this answer with the respondent who agreed to permit the

inclusion of the latter's name provided that the job title appears as it does at the beginning of this questionnaire.]

9. a. My last cost parameter for kilopacket costs was $.67. When did this increase to $1.01? We can use that parameter here!

b. Your observation that SMTP can only handle certain subsets of the ASCII character set reinforces information I had gotten some time ago. Can you provide me a specific reference? Again, we can use that here since a telecommunication "guru" (a GS-5 trainee) is being assigned to the SPO to work telecommunication issues.

c. Regarding your observation that TO update files will be "converted" to ASCII:

> 1) The ALC will already have the file in ASCII, as required by MIL-STD-1840A and MIL-M-28001A, the SGML standard.
>
> 2) No SPOs will be doing any of the data updates or transmittals. The JUSTIS SPO will be handling contracts related to JUSTIS, not the TOs JUSTIS handles. The weapon system (acquisition) SPOs will be buyers of TO data and won't be creating or holding the data.
>
> 3) I suggest you change the statement to read: "TO update files will be in ASCII at the ALCs. Depending upon the type of update format for distributing the update, a digital media could be created as a binary bit-map (raster) file for use in that format in the field. If, however, ASCII text data is required in the field, it must first be converted to a binary format to overcome SMTP limitations/problems, and then transmitted to the using base, then reconverted with 100 percent reliability back to ASCII. This conversion process results in an in-transit file that is approximately double the size of the original ASCII file."

d. No problem with the 78 GB estimate, that one is every bit as good as any others.

e. The timing of the file transfers is also in line with current plans. Again, there may be no need to reconvert from ASCII to binary if the user employs the bit-map image.

f. Encryption of the MILNET trunks within three years is GOOD NEWS! Can you get me a specific quote on that? Is it in a plan that we can rely upon?

g. Your assertion that erasable MOD will be the chosen media for TOs is premature. Erasability is encumbered with data corruption and insidious sabotage-by-alteration problems. Non-erasable media, if corrupted or altered, show up as "unreadable" or can be readily checked to determine if additional file directory blocks have been added. There are lots more arguments flying on the true economics of re-usable optical media that will forestall any decision until much later.

h. Concur on your observation concerning security audits and controls at the base level. In fact, those audits and controls must also be employed in the ALC-to-ALC transfer of TOs to assemble system-specific TO packages, for example inclusion of commodity TOs and support/test equipment in a weapon system's total package.

Fred Brun, JUSTIS Program Analyst

1. DDN and DCTN is planned for safety TOs and supplements only. This represents approximately 0.7 percent of TO pages. This was increased to 1.0 percent to account for other emergency distributions. All other distributions are planned for use of optical disks and will be made via USPS certified mail for letter and box shipments to CONUS destinations, USPS registered letter and box service for OS.

2. Transmitting and storing of TO data will be MIL-STD 1840 compliant. There should be no need to convert from binary to ASCII and back.

3. Rewritable optical disk storage will not fulfill JUSTIS system requirements. Current plans are to use disposable read-only optical disks to distribute new or revised TO data and Compact Disc (CD) Read Only Memory (ROM) to store the TO data. Feasibility and costs need be addressed in the usage of rewritable optical disk storage.

4. No.

5. No comment.

6. The above changes should be made to the model plus the following needs considered:

   a. JUSTIS will send changes overseas (OS) in addition to the fifty states.

   b. Loading of the TO changes need to be addressed, e.g extracted from a database maintained at the ALC/SPO.

   c. Interface with the users via print-on-demand or user devices should be considered.

7. Yes.

8. Yes.

9. I am in the business division of the SPO and comments are based upon the programmatic and cost assumptions used for the AFTOMS draft EA. Discussions on types

of disks and what data was distributed via "MILNET" were major discussion items with the technical division of the SPO before the assumptions were approved for the EA.

MSgt Gottschalk, TAC Liaison to JUSTIS (AFLC/LMSC/SNTL)

1. Unknown.

2. Unknown.

3. It will down to JUSTIS Tier 3, but TAC (Tier 4) wants digital data through LANs so the user doesn't encounter configuration management problems associated with optical disks.

4. No.

5. Urgent, emergency action TCTOs might require quicker distribution; however, an information message could precede the digital delivery the following morning.

6. How will the user know he is using current TO data. Would the TO updates be a separate disk that would require integration with the TO file disk? Or, would the update disk be an up-to-date rewrite of the entire TO file?

7. Yes.

8. Yes.

9.

MSgt David G. Krisch, AFCC Liaison to JUSTIS (LMSC/SNTL-AFCC)

1. MILNET is fairly crowded at the moment, and the congestion will only get worse in the future. Using SMTP would be fine for the changes as long as the changes remained in textual format. However, if graphics are to be changed, there could be a problem with the data stream depending on the MIL-STD 1840 used to create the graphic.

One other problem which may be encountered is sending changes to overseas locations and the congestion of the northeast quadrant of the USA. These places are still using ancient telecommunications lines with lots of noise. This causes several retransmissions and loss of data. Since the importance of accurate TO data cannot be stressed enough, any loss of data could be detrimental.

2. Conversion of binary to ASCII should not be a problem. I cannot say if this might be a problem in the future with digital data. The TOs will conform to MIL-STD 1840, and Technical Manual Specifications and Standards (TMSS). The TMSS will contain the information for the structure and format of the technical data, along with the format is the type of output which will be used [for] human and machine consumption. Depending on the output device, and if the originator used any special characters, the conversion may create a conflict of data bits.

3. It would be premature to say if rewritable optical disks would fulfill JUSTIS system requirements. The format for system or TO changes have yet to be established. We do not know at this time if changes will be in bulk form, patches, or in telecommunications format. Today, optical disks look pretty good, but since JUSTIS will not reach Full Operating Capability (FOC) till the late 1990s and since it is speculated that JUSTIS will incorporate a clause to use new technology to preclude fielding an outdated system, I will not give a firm acceptance to rewritable optical disks. There are just two many innovations being made in the computer world every day to lock ourselves in to one type of technology.

4. Policies and procedures are not defined in the JUSTIS Functional description at this time. These issues will be addressed in another document on infrastructure which has just been given to the Central Technical Order Management (CTOM) committee to oversee. We can only speculate that policy and procedures will play a large role in the development of the JUSTIS system. There are also some Defense Management Reviews (DMRs) which may change the entire structure of defense communications. Policy and procedures will have to be defined to limit the size of TO changes transmitted digitally. Future budgets and the strength of the printer lobbyist in Washington [,D.C.] will also shape JUSTIS. As a note, I would like to say about MILNET, "He who sends the most, pays the most." There may be budget fights brewing which we have not yet addressed.

5. The model has great potential for CONUS operations and if it could be incorporated today. The time for transmissions would have to be reworked by queuing to expect delivery at the distant end at off-peak hours. As far as I know, MILNET cannot handle data packages only ASCII. Since digital data transmission, and TMSS is not defined for digital data, this model could be limited to only textual information.

6. No, I would not favor adoption of such a model. It's not that there is something wrong, but there are just too many unanswered methods to be explored with JUSTIS itself. The long lag time for JUSTIS FOC, and the changes occurring in the DoD, would make such an adoption premature.

7. Yes, you may contact me.

8. Yes, you may cite my response.

9. In order to make your model work, you will need to limit your time period as we know it today. Your thesis will also have to include speculative infrastructure on what and how information will be passed to each tier level. Will changes be patches or will complete digital TOs be reformatted before dissemination? Will changes be limited in size, so as not to overload the system? Will MILNET be able to handle digital data streams as

opposed to ASCII? Will encryption conflict with data codes used in the TO? Will there be special handling required for encrypted data at both the sending and receiving stations? How will authentication take place? How will data be verified as correct once it is received at the distant end?

I am sure you can speculate just as well as I can, so when you build your system in your thesis, make your own policy and procedures. Your have a formidable task ahead. Good Luck!!!

Bruce L. George, Capt, USAF, Assistant Professor of Electrical Engineering, AFIT

1. Defense Data Network (DDN) connections have been known to have problems with large file transfers form time to time. You might want to check transfer characteristics with AFIT/SC to see how dependable MILNET would be.

Do you mean 128 bits per kilo packet or 128 bytes?

2. See if you can get a feel for the amount of processing time to convert typical size files. Should not be a real problem though.

3. Probably, but you might consider backup options to protect data from system failures.

4. Don't Know.

5. Saves paper. Updates should be faster and easier.

6. Sounds Ok.

7. Yes

8. Yes

9. Personnel training for a computer based system such as this should be considered.

Kim Kanzaki, Maj, USA, Instructor of Electrical Engineering, AFIT

1. Had a discussion with [Capt] Bruce George [Assistant Professor of Electrical Engineering [AFIT], I concur with his comments.

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The Joint Service Technical Information System (JUSTIS--formerly the Air Force Technical Order Management System) was chartered to improve the way in which the Air Force and other services manage technical orders (TOs). Because of the involvement that TOs have in the way the Air Force does business and over 20 million TOs that must be managed (with 2.3 million page changes annually), the effectiveness of the technical order system significanly impacts military readiness and the Air Force budget. Much of the current system does not meet today's complex Air Force needs. This report investigates the ramifications of transmitting TO changes over the Digital Defense Network (DDN)--specifically MILNET, taking into consideration cost, security, data integrity and configuration control. From an investigation of the technical order system, DDN, and digital computer storage media, a model was developed to determine the viability of the author's hypothesis. The model is a simple, straightforward description of a solution to updating TO changes. In order to determine the benefits and shortcomings in the model, a variety of experts reviewed the model and answered specific questions.

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